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The influence of extractive activities on public support for renewable energy policy

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A R T I C L E I N F O

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A B S T R A C T

Notable spatial variation in public opinion on climate change and energy policy has been demonstrated at various geographic scales (Howe et al., 2015). Understanding the source of this variation is useful for policy-makers, energy developers, and utility providers in predicting how different locales may respond to newly proposed policies and energy developments, particularly those encouraging renewable energy. Using nationally representative survey data from 2008 to 2015, we employ hierarchical linear regression to examine variation in public support for renewable energy policy, focusing on how residence in areas with extractive activities may be related to attitudes toward renewable energy policy. We test the influence of several county-level indicators, including oil production, gas production, and economic dependence on the mining sector. We also test for individual factors, including political ideology, belief in anthropogenic climate change, and several socio-demographic variables. Results suggest that individuals living in both mining-dependent counties and counties with natural gas production are somewhat less likely to support renewable energy policies than individuals living outside such places. At the individual level, belief in anthropogenic global warming is the strongest predictor of renewable energy policy support, and liberal political ideology, being more educated, and being female are also positively associated with policy support.

1. Introduction

Renewable energy technologies such as solar photovoltaic cells and wind turbines have been deployed at a rapid rate across the United States in the last fifteen years. The installed capacity of utility-scale wind energy – currently the largest renewable energy source – has grown rapidly, from 2539 MW at the end of 2000–89,077 MW by the end of the third quarter of 2017 – a 3395% growth over seventeen years (AWEA, 2017). Solar energy has also grown rapidly – including both utility-scale and rooftop solar, and solar energy installed capacity in the US was 49,300 MW at the end of 2017 (SEIA, 2017). Such rapid deployment has meant that an increasing proportion of the public is now aware of renewable energy systems. The construction of these new industrial facilities upon the landscape has spurred a variety of public reactions, both positive and negative, and opposed citizens can influence whether or not renewable facilities are permitted and built (Ogilvie and Roots, 2015).

There are many factors – social, political, physical, economic, technological – that drive or constrain the transition to a cleaner energy economy, but the role of both policy and the political environment are vital (Edenhofer et al., 2011). Governments can incentivize renewable energy investments, manufacturing, and construction through various policy tools. They can create space for renewable energy in the market by setting pollution standards and penalties for fossil fuels energy production. The use of policy tools to encourage the growth of renewable energy, however, is a political choice made by elected officials, whom all have constituents they must answer to. The politics of energy policy can thus become polarized amongst both political leaders and in the general public based on ideological stances regarding the right of the government to 'intervene' in the free market, for example by incentivizing one energy source over another through subsidies, as well as the decades old 'jobs v. the environment' debate in which regulation of polluting energy sources is portrayed as an attack on blue-collar Americans.

Much of the research seeking to understand the factors related to social opposition or support for renewable energy technologies and policy has occurred through community-scale studies and comparative case study analysis. Less work has been done at larger scales to identify

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broad, generalizable patterns that could help policymakers and developers understand the factors that influence public support for renewable energy. Understanding these dynamics is critically important, perhaps now more than ever given Americans' increasing political divisions over environmental and energy issues (Brulle et al., 2012). It is also an important piece of the larger national debate over regulation of carbon-intensive energy production, which took a turn with the 2017 inauguration of a Republican president and a Republican-controlled Congress.

This paper examines the predictive strength of several individual-level characteristics in understanding public support for renewable energy policy, as well as one group-level characteristic: the influence of living in a county with extractive activities. Local reliance on extractive industries has been shown to help predict public support for different energy sources (Boudet, 2011; Boudet et al., 2016; Bell and York, 2010; Forsyth et al., 2007; Freudenburg and Gramling, 1994; McAdam and Boudet, 2012), but less is known about whether this dynamic is at play regarding public opinion of renewable energies and policies. As such, the present research examines the following two research questions: 1) Does local presence of extractive industry activities influence public opinion about renewable energy policy? 2) What individual-level factors help predict public support for renewable energy policy?

2. Literature review

2.1. Renewable energy policy and politics in the United States

In the United States, renewable energy policy is characterized by uncertainty, contention, and fragmentation, which has stunted investments in renewable technologies (Barradale, 2010; Busby, 2008; Elliot, 2013; Ernst, 2013; Hess, 2016; Shrimali et al., 2015). Political polarization is high over environmental issues like climate change (Brulle et al., 2012), and this extends to the debate over regulation of carbon-intensive electricity sources, such as coal. The debate between political party leaders over emerging clean energy technologies has become increasingly divisive in recent years. For example, pointing to the current political polarization over the Production Tax Credit (PTC), a policy encouraging development of wind energy, Goldfarb and colleagues (2016) note that this has not always been the case. In fact, the PTC was a bipartisan issue in the 1990s, but became increasingly polarized in the 2000s. The chance to renew the PTC for a five-year period arose before the Senate in 2015. Forty-four Democrats were in favor with only one opposing the renewal, however, only three Republicans were in favor with fifty opposed. Such political polarization regarding energy policy amongst leaders and elites has also been shown to increase polarization amongst the public (Bolsen and Cook, 2008).

The United States has no federal mandate requiring increased deployment of renewable energy. Rather, the US has relied on federal tax incentives, grants, and state-level policies to encourage renewables development (Gan et al., 2007; Komor, 2004; Menz, 2005). Two of the most important federal policies supporting the development of renewable energy are two tax credit policies, the Production Tax Credit (PTC) and the Investment Tax Credit (ITC). The PTC provides a \$0.023/kWh corporate tax credit to developers of wind, geothermal, and biomass electricity generating facilities, applicable for the first ten years of production. The ITC, by contrast, offers a 30% tax credit for individual purchasers of solar systems on residential and commercial properties. Originally enacted in 1992, the PTC is in a phase-down process set to end in 2019. The ITC is enacted through 2023.

State-level renewable energy portfolio standards (RPS) are another important policy tool encouraging the growth of renewable energy. These policies are enacted by states and mandate that a certain percentage of electricity sold in that state by electric utilities be produced from renewable energy sources. Currently, 29 U.S. states and the District of Columbia have RPS mandates, and seven states have non-binding "goals." The specific renewable energy target for electricity production varies widely by state, from ten percent in Wisconsin to thirty-three percent in California (Barbose, 2013), and recent efforts to increase RPS laws in some states have been met with fierce opposition from both policymakers and industry groups.

A third avenue for supporting renewable energy is federal investment in renewable energy research and development. Federal funding for renewable energy research and development increased significantly under the Obama administration, though public support for such investments was negatively affected by the 'Solyndra debacle' of 2011, in which solar panel manufacturer Solyndra filed for bankruptcy and defaulted on a \$500 million federal loan from the US government (Bishop, 2014; Carlisle et al., 2015).

The use of policy and funding tools such as these depends greatly on the issue priorities of presidential administrations, which can vary widely. Even if a president is motivated by environmental concerns, political contention and 'veto players' (Bayulgen and Ladewig, 2016) can delay or halt the continuation of policies and the passage of legislation that would encourage more rapid growth of renewable energy. An example of this was President Obama's Clean Energy and Security Act of 2009, which would have established a carbon cap and trade system and further spurred the transition to a clean energy economy. The bill was approved by the House of Representatives, but was never brought to the Senate floor for a vote. Even when the executive branch of government tries to bypass the legislative branch, certain interests and powerful players can halt progress. This was the case with President Obama's Clean Power Plan, which aimed to reduce carbon dioxide emissions by about one-third by 2030 through growth in renewable energy deployment and regulation of existing power plants. In February 2016, the Supreme Court halted legal enforcement of the plan. Conservative party leaders and industry vigorously denounced the plan based on concerns about the economic effects and job losses – Senate Minority Leader Mitch McConnell called it "a dagger in the heart of the American middle class" (Condon, 2016).

2.2. Public opinion on renewable energy technologies and policy

Researchers analyzing general public opinion of renewable energy have found widespread support (Greenberg, 2009; Klick and Smith, 2010; Leiserowitz et al., 2017; Nisbet and Myers, 2007; Stoutenborough et al., 2015a; Truelove, 2012). However, a "social gap" exists in public views on renewable energy, and public support for renewable energy in the abstract is often complicated by community opposition to proposals for nearby construction of renewable energy facilities (e.g. Bell et al., 2013, 2005).[1] As such, the majority of research is focused on opposition or support at the local level (Bell et al., 2013; Kontogianni et al., 2014). Utility-scale renewable energy systems are highly visible, cover large areas of land, and may pose threats to citizens' local place attachment, place meanings, and place-based identities (Devine-Wright, 2009, 2011; Jacquet and Stedman, 2013). Indeed, much of the research examining local opposition to renewable energy development has found evidence suggesting opposition commonly arises from aesthetic and place-based concerns (Devine-Wright, 2011; Phadke, 2011), feelings that local community autonomy is trammeled by outside interests (Bohn and Lant, 2009; Haggett, 2011; Leitch, 2010; Pasqualetti, 2011), and concerns about distribution of the benefits and burdens of large-scale renewable systems (García et al., 2016; Haggerty et al., 2014; Ottinger, 2013).

Less research has examined why public opposition may occur at the more general, abstract level in terms of citizens' energy and policy

[1] The effect of proximity on local individuals' support for renewable energy facilities is mixed in the literature, with some studies indicating a negative association between support and closeness, other studies finding a positive association, and still others finding no association at all (see for example Jacquet, 2012; Krause et al., 2016; Olson-Hazboun et al., 2016).

preferences. Renewable energy systems can raise a variety of concerns for citizens who don't live near renewable energy sites, including worry that renewable energy will increase energy prices, that renewable energy technologies are less reliable than fossil fuels technologies for electricity production, and that renewable energy developers receive an inappropriately privileged 'leg up' via government incentives (Carlisle et al., 2015; Klick and Smith, 2010). This study focuses on how individuals' political ideology, climate change beliefs, and residence near fossil fuels extraction are associated with support for renewable energy policy. The rationale for each factor is discussed in turn below.

2.2.1. Political ideology

Political ideology has been shown to be correlated with public opinion about energy in many studies (Boudet et al., 2014, 2016; Cacciatore et al., 2012; Clarke et al., 2016; Delshad and Raymond, 2013; Goldfarb et al., 2016; Larson and Krannich, 2016; Mukherjee and Rahman, 2016), though it appears more weakly related in other studies (Ansolabehere and Konisky, 2009; Klick and Smith, 2010; Lilley and Firestone, 2013). Political conservatives often support fossil fuels over other energy sources because of concerns about job losses, support for industries reliant on cheap fossil fuels, and support for free-market ideology, while political liberals often oppose fossil fuels due to environmental concerns, including concerns about global climate change (McCright and Dunlap, 2011). In general, renewable energy is strongly supported across the political spectrum, by the majority of Democrats and Republicans, liberals and conservatives (Leiserowitz et al., 2017). However, a partisan divide still exists, with Democrats and liberals generally exhibiting more support (Carlisle et al., 2015; Goldfarb et al., 2016; Hess et al., 2016). Some researchers have found that political ideology is a weak predictor of renewable energy attitudes, with other factors such as environmental beliefs, local context, and beliefs about the economic facets of renewable energy being much more important drivers (Klick and Smith, 2010; Olson-Hazboun et al., 2016). Additionally, although Democrats are generally more supportive of renewable energy than Republicans, there is debate amongst liberals about the environmental benefits versus harms of technologies such as wind and solar energy, essentially weighing wildlife and landscape impacts against the pollution and carbon savings benefits – this has been referred to as the 'green on green' debate (Warren et al., 2005).

2.2.2. Belief in anthropogenic global warming

In general, the connection between environmental beliefs – including beliefs about climate change – and energy and policy preferences is well established (Carlisle et al., 2015; Engels et al., 2013; Greenberg, 2009; Manley et al., 2013; Mukherjee and Rahman, 2016; Truelove, 2012; Zografakis et al., 2010). Yet, while some research suggests that most Americans are concerned about the environment and that the environment is an important factor driving different energy preferences (Ansolabehere and Konisky, 2009; DeCicco et al., 2015), other studies highlight the importance of other factors such as risk perceptions and cultural barriers such as trust in the status quo (Stoutenborough et al., 2015b; Sovacool, 2009). In terms of support for renewable energy technology and policy, views on climate change may be especially important because renewable energy is often framed as a vital component of climate mitigation (Edenhofer et al., 2011).

However, while the imperative to mitigate global climate change through reduction of greenhouse gases from the burning of fossil fuels is a near-consensus point of view amongst scientists (Barnosky et al., 2012; Cook et al., 2013; Hansen et al., 2013), public opinion on climate change is highly polarized along partisan lines in the United States (McCright et al., 2014). As such, public support for policies encouraging renewable energy developing may track views on climate change, though multiple non-climate, non-environmental messaging frames exist for renewable energy. For example, renewable energy policies could be framed as unwanted government intervention in the free market or as directly threatening the security of fossil fuels jobs, which may be unappealing to those with a conservative political ideology. The same policy, however, could be framed in terms of economic growth and job creation, reducing reliance on foreign energy sources, or as a way to diversify the energy system.

2.2.3. Extractive industries and public opinion about energy

Several studies have demonstrated how reliance on the extractive sector is related to policy attitudes at both the individual and collective levels (e.g. Boudet et al., 2016; Mukherjee and Rahman, 2016). For example, one study found that how members of Congress vote on climate policy appears to depend on the carbon intensity of their districts (Cragg et al., 2012). At the level of local governments, Zahran et al. (2008) found that whether officials develop climate mitigation strategies or not depended on how prominently fossil fuels factored into the local economy. A similar correlation has also been found at the individual level. In a survey of public opinion about climate policy in Norway, Tvinnereim and Ivarsflaten (2016) found that individuals employed in fossil fuels industries were less likely to support policies that were more costly to their industry (such as reducing oil production), though they were just as likely as everyone else to support less costly climate policies (such as carbon capture technologies).

Several studies have also examined the influence that living within the vicinity of fossil fuels extraction activities may have. Even if individuals themselves are not employed by the local extractive industry, it is reasonable to expect that they would be more supportive of the industry supporting the local economy and providing family-wage jobs for their friends and neighbors (Freudenburg and Davidson, 2007). For example, residents of fossil fuels-rich states appear to be more supportive of extractive activities such as offshore drilling (Mukherjee and Rahman, 2016). Several studies have shown that individuals living in areas undergoing intense natural gas development were more likely to view hydraulic fracturing,[2] or 'fracking', positively, often for the economic development it was expected to bring (Jacquet, 2012; Kriesky et al., 2013; Rabe and Borick, 2011; Stedman et al., 2012; Theodori, 2009). In a nationally representative study of the United States, Boudet et al. (2016) find that individuals living in counties with higher employment in the natural resources and mining sector, and individuals living in a shale play area were more likely to be supportive of fracking. Similarly, Boudet et al. (2018) found that proximity to new gas development was associated with greater familiarity with and support for hydraulic fracturing. In another study, individuals who lived closer to the Keystone XL Pipeline Expansion were found to be more supportive of that project (Gravelle and Lachapelle, 2015).

However, in other instances the extraction and production of fossil fuels is perceived by the public negatively, as an environmental or social ill, and something to resist - the most recent example being the protest over the Dakota Access Pipeline. Goldfarb et al. (2016), for example, found that Americans living closer to coal-fired power plants were more supportive of renewable energy policies than those who lived further, and this effect increased when they were specifically prompted to consider the health impacts of pollution from coal burning.

These observations suggest that community-level factors such as local economic reliance on or proximity to particular industries could be as influential as individual factors in shaping public attitudes toward energy, positive or negative (Bell and York, 2010; Freudenburg and Davidson, 2007). Communities may become 'overadapted' to particular types of employment, making it difficult to envision or implement changes as larger economic and production systems shift around them (Gramling and Freudenburg, 1992). Freudenburg (1992) argued that communities become 'addicted' to the prosperous times inherent in

[2] The term "hydraulic fracturing" or "fracking" here is used to denote the relatively recent technological innovation of using directional drilling in tandem with hydraulic fracturing (which by itself has been used for many decades) to extract hard-to-reach oil and gas reserves.

extractive economies, which are characterized by 'boom-bust' economic cycles.

Community support for the fossil fuels industry and the broader extractive sector can also work through the mechanism of collective identity. Scholars have argued that identity can form at a collective level, coalescing around phenomena or shared experiences such as local culture, social norms, landscape features, and predominant occupations or industries (Bell and York, 2010; Carroll, 1989; Kreye et al., 2016; Puddifoot, 1996; Reeve et al., 2013; Rich, 2016). Collective identity influences how communities respond to threats, such as natural hazards or new environmental regulations, and how members form opinions and understandings of issues (Bell and York, 2010; Kreye et al., 2016; Messer et al., 2015). For example, Kreye et al. (2016) highlight the relevance of community identity in understanding how Florida cattlemen view and respond to new governmental policies to protect panthers.

Scholars have argued that a "community economic identity" forms when a locale is so dominated by one industry that it shapes local beliefs, norms, and culture (Bell and York, 2010; Freudenburg and Davidson, 2007; Freudenburg and Gramling, 1994; Gramling and Freudenburg, 1992). For example, Evans and Phelan (2016) argue that "…coal mining has provided material wellbeing and led to particular habitual, institutional, and discursive formations in the region that have formed 'mining' identities of individuals and communities" (p. 332). Bell and York (2010) and Bell (2016) found the same to be true in the coal field communities of Appalachia, where residents' community economic identity was strongly tied to persistent loyalty to the coal mining industry, even as the industry perpetuates significant social and environmental injustices.

While both economic reliance on and processes of identity and culture are both tied to support for extractive industries, little is known about how these dynamics might shape support for alternative energy sources or policies. In the case of renewable energy policy, support may be constrained by the perception of threat to both identities and economic wellbeing. To date, we could only find one study that specifically analyzes the influence of extractive industries on renewable energy policy attitudes (Goldfarb et al., 2016, discussed above). In the present study, we hypothesize that renewable energy policies are perceived as less desirable to individuals in places where extractive industry activities are occurring. Though these individuals and communities could possibly benefit from renewable energy development through construction jobs, lease payments to landowners, and increased local tax revenue, it is likely that they would instead oppose policies fostering renewable energy development because of a perceived threat to the local economy and collective identity.

3. Data

3.1. Survey data and dependent variable measures

The data for our dependent variable indicating individuals' level of support for renewable energy policies comes from thirteen waves of the Climate Change in the American Mind (CCAM) survey project (mean n = 1155 per wave). The CCAM surveys are nationally representative surveys conducted between 2008 and 2015 by the Yale Program on Climate Change Communication and George Mason Center for Climate Change Communication. For details on each of the survey waves used in our study, including the dates the surveys were fielded, the sample size, margins of error, and response rates, please see Appendix A.

The data from the separate survey waves were merged into a single combined data set. After removing missing responses from variables of interest, our total sample was 13,233 respondents, who resided in 1952 different U.S. counties in 49 states (Alaska was excluded). Data were collected through online surveys conducted by GfK Knowledge Networks. The company recruited the nationally representative panel of individuals using random-digit dialing and addressed-based sampling to make sure that non-landline households were also included in the sampling frame, then conducted the data collection using a probability-based online panel. The company provides computers and internet access to households without them and includes small incentives to encourage participation. Latitude and longitude coordinates were provided for each respondent based on their home address, which we used to determine respondents' county of residence.

To produce an overall measure of "support" for renewable energy policy, we created a summated rating scale from three survey questions asking for respondents' attitudes on a variety of policy issues related to renewable energy. Briefly, these three items were: 'How much do you support or oppose the following policies?' a) Fund more research into renewable energy sources, such as solar and wind power; b) Require electric utilities to produce at least 20% of their electricity from wind, solar, or other renewable energy sources, even if it costs the average household an extra $100 a year; and c) Provide tax rebates for people who purchase energy-efficient vehicles or solar panels. The scale produced from these three items had high reliability (Cronbach's alpha = 0.81), suggesting an acceptable internal consistency for measuring individuals' overall level of support for policies encouraging the growth and use of renewable energy. Further details of this and other survey-based measures are provided in Table 1.

3.2. Primary independent variables: extractive industry activities

To measure the influence of extractive industry activities on individuals' level of support for renewable energy policy, we focus on two measures of 'extractive industry activity'. First, we examine the influence of county-level oil and gas production. Second, we examine the influence of county-level economic dependency on the mining sector.

To identify active oil and gas production in counties, we use data from the US Department of Agriculture Economic Research Service (USDA ERS, 2015, 2004) on county-level oil and gas production (Low et al., 2014). This dataset includes oil and gas production up to the year 2011. We examine oil and gas production separately. We grouped the oil and gas production data into the four years relevant to the survey data collection time period (which began in fall 2008) and created binary variables indicating production accordingly. Counties in which oil or gas production was reported for any of the years from 2008 to 2011 received a "1", while counties in which no oil or gas production occurred during these years received a "0."[3] To capture any effect of this variable that may have been in place before the 'boom' in oil and gas production in the late-2000s, we also included a binary variable indicating whether oil or gas production was reported in the year 2000 (the earliest year available).

According to the ERS data, there were 980 gas-producing counties and 1005 oil-producing counties in the US with production present any year from 2008 to 2011 (excluding Alaska and Hawaii). In terms of coverage of major energy counties, our survey dataset includes respondents from fifty-six of the top one hundred gas-producing counties and forty-seven of the top one hundred oil-producing counties. As shown in Table 1, about 30% of our respondents lived in a county that produced natural gas in 2008–2011, and about 30% lived in a county producing oil for those years.

To indicate county-level economic dependency on the mining sector, we use the county typology code for "mining dependency" created by the USDA ERS (2015, 2004). We considered two versions of this classification system, both the 2004 and 2015 versions. The ERS

[3] Boudet et al. (2016) use a similar binary measure for oil and gas production. We explored various categorical variable configurations for of oil and gas production to capture any effects based on level of production. However, the effect was in the same direction as the dichotomous variable, and so for simplicity (and to keep the overall number of variables in the model to a minimum) we use the binary variable in our models.

Table 1
Variable measurements, sources, and descriptive statistics.

Variable	Question(s)/measurement	Source	Descriptive statistics
Renewable energy policy support	Summated rating scale (Cronbach's alpha = 0.81) derived from three items.	CCAM	*Range:* 0–9, *M: 5.85*, *SD:* 2.35
Sex	1 = Male, 0 = Female	CCAM	Male: 50.11%
Age	Age in years	CCAM	*M:* 49.74, *SD:* 16.49 (Min = 18, Max = 97)
Race	1 = Non-white, 0 = White	CCAM	Non-white: 22.90% White = 77.10%
Education	0 = High school or less, 1 = Some college, 2 = Bachelor's degree or higher	CCAM	High school or less: 37.58% Some college: 29.65% Bachelor's or higher: 32.78%
Political ideology	1 = Very liberal, 2 = Somewhat liberal, 3 = Moderate/middle of the road, 4 = Somewhat conservative, 5 = Very conservative	CCAM	*M:* 3.17, *SD:* 1.05
Belief in anthropogenic global warming (AGW)	1 = Caused mostly by humans, 0 = Not happening and/or not caused by humans	CCAM	Belief in AGW: 50.58%
Metro county	1 = Metro, 0 =;Nonmetro	USDA ERS	Within metro county: 85.60%
Natural gas production, 2008–2011	1 = Natural gas production reported in county for any year from 2008 to 2011, 0 = No production reported	USDA ERS	Within gas-producing county: 29.06%
Oil production, 2008–2011	1 = Oil production reported in county for any year from 2008 to 2011, 0 =;No production reported	USDA ERS	Within oil-producing county: 30.31%
Natural gas production in 2000	1 = Natural gas production reported in county for 2000, 0 = No production reported for 2000	USDA ERS	Within gas-producing county: 27.94%
Oil production in 2000	1 = Oil production reported in county for 2000, 0 = No production reported for 2000	USDA ERS	Within oil-producing county: 28.59%
2004 classification as mining-dependent county	1 = County meets ERS 2004 definition of "mining dependent",[a] 0 = County is not "mining dependent"	USDA ERS	Within 2004 mining-dependent county: 0.90%
2015 classification as mining-dependent county	1 = County meets ERS 2015 definition of "mining dependent",[b] 0 = County is not "mining dependent"	USDA ERS	Within 2015 mining-dependent county: 3.17%

[a] Mining industry "accounted for annual average of 15% or more of total county earnings during 1998–2000".
[b] Mining industry "accounted for annual average of 13% or more of total county earnings or 8% or more of total county employment from the years 2010–2012".

defines mining as "including metal; coal; oil and gas; stone; sand and gravel; clay, ceramic, and refractory minerals; chemical and fertilizer minerals; and miscellaneous nonmetallic minerals, such as gem stones, diatomaceous earth, peat, and talc." The 2004 classification of "mining dependent" counties was based on that county relying on the mining sector for an annual average of 15% or more of total county earnings during 1998–2000. In the 2015 edition, the ERS defined a county as 'mining dependent' if the mining industry accounted for "an annual average of thirteen percent or more of total county earnings or eight percent or more of total county employment from the years 2010–2012." We included both measures as independent variables, though we analyzed their influence in separate models to avoid overfitting due to multicollinearity.

3.3. Political ideology and belief in anthropogenic climate change

Since political views have been shown to be important for predicting public views on a variety of environmental and energy issues (see literature review above), we include political ideology as a predictor variable, measured by asking respondents to place themselves on a scale from "very conservative" to "very liberal."

Additionally, we predict that support for renewable energy policy is at least partly a factor of individuals' belief in anthropogenic climate change. We include a predictor variable from the CCAM survey that indicates whether the respondent believes that global warming is at least partly caused by humans.

3.4. Additional independent variables

Individual-level demographic variables were derived from the CCAM dataset described above. We include gender, age, race, and education as demographic control variables. Age and education have been identified as relatively stable predictors of public views on environmental issues (Jones and Dunlap, 1992; Van Liere and Dunlap, 1980), while the effect of gender has received mixed and inconsistent support, though women generally exhibit higher levels of concern, especially in terms of health and safety risks of environmental problems (Davidson and Freudenburg, 1996; Dougherty et al., 2003; Xiao and McCright, 2012).

Education has been shown in various studies to be a relatively stable predictor of public attitudes on various environmental issues, with higher education levels typically corresponding to greater levels of environmental concern (Diamantopoulos et al., 2003; Dunlap et al., 2001; Jones and Dunlap, 1992; Xiao and Dunlap, 2007). However, the results have been more mixed when specifically examining public energy preferences, with some studies showing higher education being related to support for fossil-fuels related technologies such as 'fracking' (Boudet et al., 2016, 2014), other studies reporting no association (Clarke et al., 2016; Larson and Krannich, 2016), and yet other studies showing higher education being related to support for non-fossil fuels technologies such as renewable energy (Olson-Hazboun et al., 2016).

Rural/urban differences have been demonstrated in some studies of public views on environmental issues (Freudenburg, 1991; Huddart-Kennedy et al., 2009), and so we include whether the county is urban or rural, using the ERS two-category classification system for "metro" or "non-metro" county.[4]

Last, we control for time by including a categorical variable in the model for each year of the survey, from 2008 to 2015.

4. Methods

To examine the relationship between extractive industry activities and public attitudes toward renewable energy policy, we use the Stata SE software package (version 14) to employ a multilevel regression modeling strategy, also called hierarchical linear modeling or mixed-effects modeling. We use the *mixed* command to fit our model using maximum likelihood estimation. In mixed-effects modeling, data are nested according to hierarchical structures, such as county, state, and region. Since we are interested not only in the effect of individual-level

[4] We also tested more refined measures of rurality from the Economic Research Service – both the 12-level scale "Urban Influence Code" as well as the 9-level "Rural-Urban Continuum Code." Neither showed a relationship with the dependent variable (extremely small coefficients and did not meet the threshold for statistical significance). Thus, we stuck with the simple binary measure of "metro" and "non-metro" county.

variables, such as demographic characteristics and belief in anthropogenic climate change, but also county-level characteristics, this approach is appropriate given that we are hypothesizing that both our outcome and our predictor variable may be spatially autocorrelated.

Furthermore, while some county-level variation in public attitudes is captured in the energy variables, other determinants of variation may not be captured. Public attitudes may also vary at larger scales, such as by states or region (Howe et al., 2015). Using a hierarchical modeling strategy helps accommodate missing drivers of public attitudes because it allows for both fixed and random effects at different spatial scales. In our study, we nest our data by county and state, and account for random effects at each level. Since we have both individual and county-level data, we also examine fixed-effects of these factors on the dependent variable.

We first estimate an empty multilevel linear regression model to examine geographic variation at the individual, county and state level (Model 1). We originally tested variation by U.S. Census regions in addition to the county and state level, but the variance by regions proved very low, so we left this out of the final models. We then add individual-level variables and the survey-year time variable to examine the fixed effects of these controls (Model 2). Last, we added the extractive industry variables in two separate models, one each for the earlier and later energy variables (Models 3 and 4).[5] We provide regression equations for each model in Appendix B.

5. Results and discussion

5.1. Results

Table 2 presents results from the multilevel linear regression models predicting public attitudes on renewable energy policy. The results from the multilevel models are separated into two groups. The top group reports the fixed-effects coefficients, and the bottom group reports the variances from the random-effects variables and model characteristics.

Overall, respondents were relatively supportive of renewable energy policy, with a mean score of support at 5.85 on a 0–9 scale. Our findings for the individual-level variables (Model 2) indicate that individuals who have at least some college education (0.270***) or a bachelor's degree (B = 0.350***) and individuals who believe that climate change is at least partly caused by humans (B = 1.379***) are more supportive of renewable energy policies. Conversely, being male (B = -0.164***) and identifying as politically conservative (B = −0.607)*** are both correlated with lower levels of support for renewable energy policy. While the results indicate that age has a statistically significant relationship with policy attitudes, the effect size is negligible.

Additionally, the results for the survey year variables indicate that, on average, survey participants in all survey years after the initial wave in 2008 were less supportive of renewable energy policy. The effect is the strongest in survey waves occurring during 2012, 2013, and 2014, with the strongest relationship between survey year and the dependent variable occurring in 2013. The coefficient for the 2013 variable, for example, suggests that respondents in the 2013 survey waves on average scored a point lower on the support for renewable energy policy scale (B = −0.997***).

In terms of the relationship between industry activities and support for renewable energy policies, we find evidence suggesting that individuals residing in a county with extractive industry activities are on average less supportive of such policies. The strength of the relationship depends on the extractive industry measure used, as well as the time period. Looking first at the earlier county-level extractive industry activity measures (Model 3), we find respondents who live in a county that was economically dependent on the mining sector as of 1998–2000 were on average a half a point lower on the support for renewable energy policy scale than other respondents (B = -0.597**). Looking at the coefficients for natural gas and oil production in the year 2000, neither variable met the threshold for statistical significance in their relationship with the dependent variable (though the natural gas production variable came close to this threshold at p = 0.071).

The county-level extractive industry variables for the later time period (Model 4) also yielded mixed results suggesting some relationship between extractive industries and support for renewable energy policies. County economic dependence on mining in 2010–2012 was again negatively related to respondents' level of support for renewable energy policy, though the effect was smaller than in the previous model (B = -0.250*). Individuals living in counties that reported natural gas production at some point between 2008 and 2011 were also significantly less likely to support renewable energy policy (B = −0.140*) than individuals who did not live in counties with natural gas production. The coefficient for oil production in this time period was not statistically significant.

Table 2
Multilevel model results predicting support for renewable energy policies.

	M1	M2	M3	M4
Intercept	5.853***	7.400***	7.445***	7.431***
Individual Factors (level 1)				
Gender (1: male, 0: female)		−0.164***	−0.163***	−0.163***
Age		0.003**	0.003**	0.003
Race (Non-white)		−0.049	−0.045	−0.045
Education (ref. group = H.S. or less)				
Some college		0.270***	0.265***	0.267***
Bachelors degree		0.350***	0.348**	0.346***
Political ideology (conservative)		−0.607***	−0.606***	−0.605***
Belief in anthropogenic global warming		1.379***	1.378***	1.380***
Survey year (2008 is ref.)				
2010		−0.350***	−0.351***	−0.349***
2011		−0.454***	−0.455***	−0.451***
2012		−0.794**	−0.797***	−0.792***
2013		−0.997***	−1.001***	−0.996***
2014		−0.845***	−0.847***	−0.845***
2015		−0.536***	−0.539***	−0.537***
County Factors (level 2)				
Metro county			−0.001	−0.001
Active gas production (2000)			−0.134	
Active oil production (2000)			0.063	
Mining dependent (1998–2000)			−0.597**	
Active gas production (2008–2011)				−0.140*
Active oil production (2008–2011)				0.071
Mining dependent (2010–2012)				−0.250*
Model characteristics				
n (level 1, individuals)	13,233	13,233	13,233	13,233
n (level 2 units, counties)	1952	1952	1952	1952
n (level 3 units, states)	49	49	49	49
Level 2 variance (counties)	0.105	0.006	0.005	0.004
Proportional chg. in Level 2 variance[a]	–	94.29%	95.24%	96.19%
Level 3 variance (states)	0.042	0.008	0.004	0.005
Proportional chg. in Level 3 variance[a]	–	80.95%	90.48%	88.10%
Akaike information criterion	59,875	56,194	56,186	56,189

Unstandardized regression coefficients.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
[a] Percent change in variance from null model.

[5] We examined the gas production, oil production, and mining dependency variables for multicollinearity. However, our postestimation tests indicated that multicollinearity was not a problem, with the Variance Inflation Factor (VIF) for all independent variables registering at below 5, and the Tolerance for all independent variables registering at greater than 0.1.

Lastly, individuals living in metro counties and non-metro counties do not appear to be significantly different in terms of their support for renewable energy policy.

Overall, the indicators of model fit suggest that both individual, micro-level factors as well as county-level extractive industry activities help to explain individual attitudes toward renewable energy policy nationwide, reducing the overall geographic variance from the null model at both the county and the state level. Notably, the coefficients for the statistically significant extractive industry variables are comparable in terms of effect size with several of the significant socio-demographic variables, such as gender and education. Also notable is that the measure indicating residence in a mining dependent county (1998–2000) has roughly the same level of influence on the dependent variable as political ideology.

5.2. Discussion and proposed explanations

We find that individuals residing in counties with natural gas production exhibit lower support for policies fostering renewable energy development. It is not surprising that oil production did not show up as significant in our model - while natural gas is used in the production of electricity, oil is used primarily in transportation (the use of oil-fired power plants has been phased out in the United States over the last few decades). It would stand to reason that communities partly reliant on natural gas extraction could feel threatened by new sources of energy that could be seen as being in direct competition with more traditional electricity-generating energy sources.

We also find that individuals residing in mining-dependent counties have lower levels of support than individuals in other counties. It is easy to understand why individuals in mining-dependent counties that economically rely on coal mining or coal-fired electricity generation would feel threatened by renewable energy policies. Communities that have suffered from the retirement of coal plants and closure of coal mines over the last decade may quickly connect coal's demise with the climate mitigation policies emphasized over the two terms of the Obama administration during which most of our surveys occurred, such as the Clean Power Plan, which both regulated carbon pollution from coal burning as well as incentivized renewable energy development. However, we find this result interesting given that over forty percent of survey respondents were from mining-dependent counties where coal mining did not occur, but where some other type of mining was dominant. In this case, lowered support for renewable energy policies may not be related to worry that renewables would replace the local fossil fuels economy, but instead have more to do with incongruence with collective identity, culture, and history of long-standing extractive economies.

Looking to other variables, we note that both political ideology and belief in anthropogenic global warming maintain a consistently strong relationship with support for renewable energy policy. For every point increase in the five-point liberal-conservative scale, individuals were predicted to be 0.6 points lower in support for renewable energy policy. These findings are consistent with studies finding a relationship between liberal political ideology and public support for renewable energy policy and technologies (Carlisle et al., 2015; Goldfarb et al., 2016; Hess et al., 2016). This is perhaps partly explained by the neoliberal leaning of the conservative political platform to reject proposals that can be interpreted as government ‘intervention’ in the free market (Carlisle et al., 2015; Klick and Smith, 2010), such as tax credits or renewable energy mandates placed on electricity producers. Our results also demonstrate that individuals who think that humans are at least partly influencing the climate are on average about 1.4 points higher on the scale of support for renewable energy policies than other respondents. These results are consistent with research showing that various environmental attitudes and beliefs are important drivers of the public's energy preferences (Ansolabehere and Konisky, 2009; DeCicco et al., 2015; Larsen and Krannich, 2016).

Considering some of the socio-demographic variables, both gender and education were associated in our models with support for renewable energy policy, with males expressing less support than females, and those with more education expressing higher support than those with less education, all else being equal. These findings are consistent with past research on public energy preferences – women are typically less supportive of energy technologies perceived as risky, such as hydraulic fracturing or nuclear energy, than are men (Boudet et al., 2014, 2016; Clarke et al., 2016), and are more supportive of renewable energy (Olson-Hazboun et al., 2017, 2016; Larson and Krannich, 2016). The overrepresentation of males in extractive industries could partly explain this, since policies encouraging renewable energy development could be seen as threatening their livelihoods.

The association of education with energy preferences has generated more mixed results in past studies. Here, we find that respondents with higher levels of education are more supportive of renewable energy policies than those with less. This is true both for individuals with only some college as well as those who have attained a bachelors degree – both are more supportive than individuals who have no college experience.

Looking to the variable indicating how survey timing may influence public views on renewable energy policy, the results indicate that respondents were more supportive of renewable energy policy if they took the survey in 2008 than any other year. This may be related to the effect of the Great Recession of the late 2000s, which had not fully taken effect when the 2008 survey was fielded in the fall of that year. Some research has suggested that declining public concern about environmental issues such as climate change is related to economic insecurity exacerbated by the recession, among other factors (Brulle et al., 2012; Carmichael and Brulle, 2016; Scruggs and Benegal, 2012). However, a recent study examining national survey data from 2008 to 2011 calls this relationship into question, suggesting that public views on climate change and support for policy action are more heavily influenced by changing cues from political elites – especially the rise of the Tea Party – than by economics (Mildenberger and Leiserowitz, 2017).

6. Conclusions and policy Implications

This study builds on the literature examining public responses to renewable energy as well as research on generalized public energy preferences. Previous research in this area has been primarily conducted at the community level or through comparison across several communities. This research presents a broader look at how spatial or locally relevant characteristics may influence public views of renewable energy policies. We find a relationship between extractive activities, including dependence on the mining sector and natural gas production, and lowered support for policies that encourage the use of renewable energy. These findings suggest the importance of considering community-level experiences with extractive industries in analyses of public opinion on environmental issues, and provides some explanation for the geographic variance found by Howe et al. (2015). More broadly, the importance of county-level extractive activities speaks to the importance of considering spatially relevant variables in statistical modeling, rather than only relying on individual-level predictors.

Some limitations to this research are worth pointing out. First, for simplicity, we used a binary independent variable indicating the presence or absence of oil and natural gas production. While we found a relationship showing individuals living in a county that has oil or gas production and were less likely to be supportive of renewable energy policies, this is a relatively coarse measure of oil and gas production. Thus, future analyses could extend this work by examining whether attitudinal thresholds exist at various oil and natural gas production levels. Additionally, this work considers only production levels for oil and gas, not development activities. Since drilling activity (which can be measured as the number of oil ‘spuds,’ or initial drill pads, that have

been established) is not the same as production activity, it could be interesting to include an independent variable that indicates drilling activity in a model of public support for renewable energy policy. Last, because we used the ERS measure of economic dependence on the mining sector, the relationship between residence in mining dependent counties and support for renewables policy is not as clear as it could be because this variable includes fossil fuels and non-fossil fuels mining activities.

Our results suggest that the economy-versus-environment debate is a component of public views on renewable energy policies, especially in communities that depend economically on fossil fuels industries. For policymakers, this research indicates that finding ways to emphasize the economic benefits of renewable energy could help build public support for policies encouraging its growth. Other researchers have suggested that policies that use a 'carrot' approach and promote the economic growth potential of green industries are likely to be the most successful, rather than polices using a 'stick' approach, such as a carbon tax (Brown and Hess, 2016; Meckling et al., 2015; Tvinnereim and Ivarsflaten, 2016).

This research also indicates that individual-level factors remain important in understanding public views on energy. In our study both political ideology and belief in anthropogenic climate change were strongly related to the level of support individuals show for renewable energy policies, as suggested by other research (Ansolabehere and Konisky, 2009; Boudet et al., 2016; Cacciatore et al., 2012; Clarke et al., 2016; DeCicco et al., 2015; Delshad and Raymond, 2013; Goldfarb et al., 2016; Larson and Krannich, 2016; Mukherjee and Rahman, 2016). Indeed, energy policy is embedded into national and global dialogues about climate change (Barry et al., 2008; Goodman, 2016; Pralle and Boscarino, 2011; Stephens et al., 2009), yet climate change has been increasingly politically charged and divisive in places like the United States (Brulle et al., 2012). Thus, renewable energy policies may be more likely to be championed as bi-partisan issues if connected to rationales beyond simply the imperative to mitigate climate change. Message framings that would likely help promote renewable energy technology and policies across partisan groups include economic development, domestic energy security, electricity portfolio diversification, and stable pricing for consumers, among others. Additionally, while political polarization is high on the issue of climate change, the non-climate environmental benefits of renewable energy, such as promotion of better air quality, are much less divisive and could garner support across individuals with differing political views (Goldfarb et al., 2016).

Overall, this research provides clues not only as to what types of individuals may be especially disapproving of renewable energy policies, but also where these individuals or communities may be concentrated and what place-based factors may be important in shaping public views. Social science research must continue to examine the underlying mechanisms driving political polarization over climate change mitigation strategies, such as transitioning to low-carbon sources of electricity. Our research here suggests that local reliance on extractive industries is a piece of the puzzle. For policymakers, this suggests that addressing concerns related to the decline of fossil fuels industries will be an important component – perhaps, in some regions, a prerequisite – of passing legislation accelerating the low carbon transition.

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Appendix A. Survey wave details, "Climate change in the American Mind"

Wave	Dates fielded	Completed responses	Sampling error margin (at 95% confidence level)
November 2008	Oct 7-Nov 12	2164	± 2 points
January 2010	Dec 24-Jan 3	1001	± 3 points
June 2010	May 14-June 1	1024	± 3 points
May 2011	Apr 23-May 12	1010	± 3 points
November 2011	Oct 20-Nov 16	1000	± 3 points
March 2012	Mar12-Mar 30	1008	± 3 points
September 2012	Aug 31-Sept 12	1061	± 3 points
April 2013	Apr 10–15	1045	± 3 points
November 2013	Nov 23-Dec 9	830	± 3 points
April 2014	Apr 15–22	1013	± 3 points
October 2014	Oct 17–28	1275	± 3 points
March 2015	Feb 27-Mar 10	1263	± 3 points
October 2015	Sept 30-Oct 19	1330	± 3 points

Appendix B. Regression equations

Model 1

$$y_i = \beta_0 + \alpha_{state[i]} + \alpha_{county[i]} + \in_i$$

where y_i is predicted support for renewable energy policies for respondent i, β_0 is the regression intercept, $\in$ is an error term, and,

$$\alpha_{state} \sim N(0, \sigma^2{}_{state}), \text{ for } state = 1, \ldots, 49$$
$$\alpha_{county} \sim N(0, \sigma^2{}_{county}), \text{ for } county = 1, \ldots, 1952$$

where α_{state} and α_{county} are random effects for each state and county surveyed, respectively.

Model 2

Model 2 adds individual-level predictors including gender, age, race, education, political ideology, belief that global warming is caused by humans, and the year of the survey to the above model as follows:

$y_i = \ldots + \beta_{gender} \cdot gender_i + \beta_{age} \cdot age_i + \beta_{race} \cdot race_i + \beta_{edu:somecoll} \cdot edu{:}\ somecoll_i +$
$\beta_{edu:bachelors} \cdot edu{:}\ bachelors_i + \beta_{ideology} \cdot ideology_i + \beta_{beliefgw} \cdot beliefgw_i + \beta_{year10} \cdot year2010_i +$
$\beta_{year2011} \cdot year2011_i + \beta_{year2012} \cdot year2012_i + \beta_{year2013} \cdot year2013_i + \beta_{year2014} \cdot year2014_i +$
$\beta_{year2015} \cdot year2015_i + \in_i$

Model 3

Model 3 adds county-level predictors (γ) to the above model, including designation as a metropolitan or non-metropolitan county, active gas production in 2000, active oil production in 2000, and classification as a mining-dependent county in 1998–2000 as follows:

$\alpha_{county\,[j]} \sim N\,(\gamma_{0[j]} + \gamma_{metro} \cdot metro_{[j]} + \gamma_{gas2000} \cdot gas2000_{[j]} + \gamma_{oil2000} \cdot oil2000_{[j]} +$
$\gamma_{mining1998} \cdot mining1998_{[j]},\ \sigma^2{}_{county})$, for $county = 1, \ldots, 1952$

Model 4

Model 4 substitutes the county-level energy predictors in the above model with active gas production in 2008–2011, active oil production in 2008–2011, and classification as a mining-dependent county in 2010–2012 as follows:

$\alpha_{county\,[j]} \sim \mathrm{N}(\gamma_{0[j]} + \gamma_{metro} \cdot metro_{[j]} + \gamma_{gas2008} \cdot gas2008_{[j]} + \gamma_{oil2008} \cdot oil2008_{[j]} +$
$\gamma_{mining2010} \cdot mining2010_{[j]},\ \sigma^2{}_{\alpha\,[j]})$, for $county = 1, \ldots, 1952$

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